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ON REGENERATION AND THE RE-FORMATION OF LUNULES IN MELLITA[1]

THE ambulacral lunules of the genus *Mellita* are characteristically developed by the inclusion of reëntrant marginal notches; except that in *M. sexiesperforata* these lunules, like the interambulacral lunule in this and in related genera, is formed by resorption through the test.[2] In a few species the ambulacral lunules are permanently maintained as open marginal notches, and Jackson[3] has called attention to the fact that in *Encope annectans* Jackson, the adult interambulacral lunule is represented by mere dorsal and ventral furrows, not sufficiently deep to meet and form a hole through the test. In view of the possibly exceptional character of the formation of the ambulacral lunules in *M. sexiesperforata,* note may be made of the manner in which the lunules of this species are re-formed during regenerative changes consequent upon natural injury. For in collections of *Mellita* comprising half-a-dozen or more individuals of adult size it is rarely found that every specimen presents a complete and regular marginal outline. The degree of irregularity is in most instances not large, but in some cases amounts, at the deepest point, to a radial deficiency of 13 mm. in a specimen 12 cm. in transverse diameter. I have found no irregularities of this character in specimens less than 8 cm. in transverse diameter. The nature of these deficiencies is such as to suggest that they have been inflicted by other bottom-feeding animals, possibly fishes. The wound-surfaces seem, however, to be readily covered over; and the various degrees of alteration toward a more perfect outline, exhibited in different specimens, show that relatively complete restitution is possible.

It is a noteworthy fact that these injuries are almost entirely confined to that end of the animal which is morphologically the posterior (cf. Figs. 1, 2, 3). It seems to me possible that this fact may be understood upon the assumption that when burrowing the anatomically anterior end of the "sea plate," which is somewhat more sharply pointed than the posterior, is the one

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[1] Contributions from the Bermuda Biological Station for Research.

[2] Agassiz, A., "Revision of the Echini," pp. 320–324. Clark, H. L., 1904, "Echinoderms of the Woods Hole Region," *Bull. U. S. Bur. Fish.* for 1902, pp. 545–576 (p. 565).

[3] Jackson, R. T., 1917, *Proc. U. S. Nat. Mus.*, Vol. 53, pp. 489–501 (p. 494).

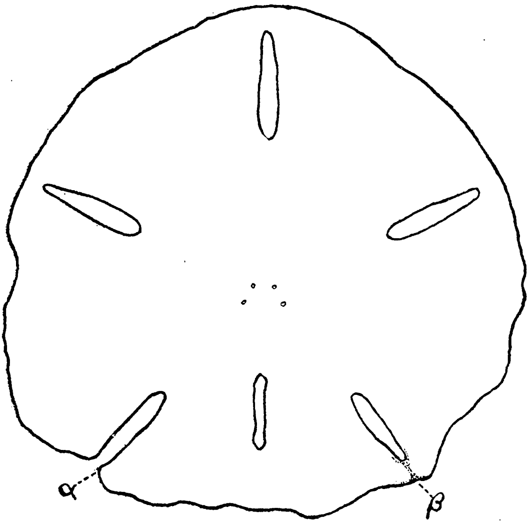

Fig. 1.

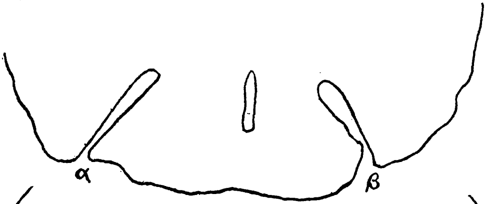

Fig. 2.

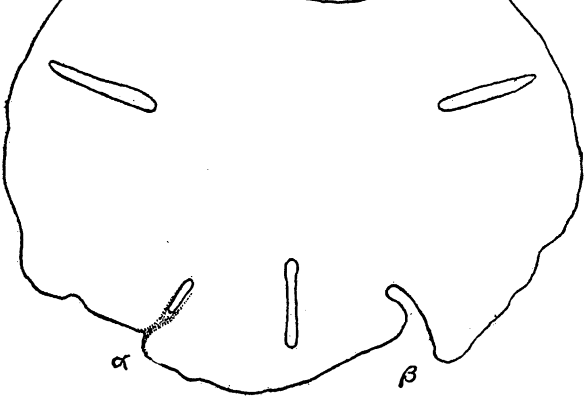

Fig. 3.

Fig. 1. Outline of a *Mellita sexiesperforata* showing at α and at β two stages in the re-formation of a posterior lunule. At β a furrow, deeper on the ventral surface, marks the region of union of the material from the two interambulacra. (× 1.) From life.

Fig. 2. Another case, showing lunules 1 and 5 in process of being closed. (× 1.) From living animals.

Fig. 3. At α the concrescence of the old lunule-walls has been carried to an extent such that the distance between the distal end of the lunule and the margin of the disc is actually greater than in the case of a lunule normally formed. Here also the furrow indicated by shading is deeper on the ventral surface. At β, deformation of a lunule through growth after injury. (× 1.) From life.

which is carried ahead.[4] These animals do burrow beneath the surface of the sand when the weather is at all stormy, and, if this assumption be valid, the posterior end might then be exposed (or even separated somewhat from the bottom) to a greater extent than at other times. If the process of emergence from the sand is somewhat different from, or quicker than, that involved in burrowing, one could understand why the anterior end is rarely, if ever, damaged, as might otherwise be expected if differential exposure of some kind alone determines the incidence of injuries; there are, of course, other possibilities.

However they originate, the restorative phenomena which these posterior injuries entail show that the ambulacral lunules of *M. sexiesperforata* May, in regeneration, follow a method of formation resembling, in a measure, that adhered to in the normal development of these lunules by other mellitas. The individuals herewith depicted in outline (Figs. 1, 2, 3) exhibit several stages in a process of lunule-completion through the concrescence of the growing edges of the disc. It is difficult to decide whether this process is of a specific regulatory character, "aiming at" the reconstitution of the lunules, or whether it represents merely the inevitable consequence of ordinary (though accelerated) growth at the margin of the mellita disc, and is, perhaps, for this reason, devoid of any recapitulatory significance. An inspection of Fig. 1 will show that at α there is evident a decided out-bulging of the disk-margin, at the point of union with the old outline of the lunule. This out-bulging, seen also at β in Fig. 2, and at β in Fig. 3, shows definite growth of the tissue toward the opposite lunule-wall in interambulacrum *V*. At β in Fig. 1 an outgrowth of this type has met and fused with a less extensive outgrowth from the opposite lunule-boundary; here, as at α in Fig. 2, it will be noted that the lateral extension of interambulacral area *V* is not confined merely to the margin of the disc, but affects also the whole lateral wall of the lunule on that side,—provided the injury be sufficiently extensive—so that closure of the lunule is slow. If the original disturbance be small, as at β in Fig. 1, this and other similar cases show that reparation may be relatively complete. On the other hand, more extensive injury, as at β in Fig. 3, seems to result in "regeneration" which is not so quickly effective as, for example, in β, Fig. 1; under these circumstances the posterior extension of the substance of interambulacrum *I*, not met by growth from interambulacrum *V*, produces a relatively considerable distortion of the old lunule. Moreover, the coalescence of the lunule-walls may be carried to a length which seems greater than it need be, as a *a* in Fig. 3. For these reasons the idea of a specific regulatory character in the re-formation of the lunule seems unnecessary.

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[4] Cf. Cole, L. J., 1913, *Jour. Exp. Zool.*, Vol. 14, pp. 1–32.

It would be of interest to observe the effect, upon the course of regeneration, of an injury deep enough to remove the area of a lunule down to its proximal border; I have seen no cases of this kind, nor any in which the interambulacral lunule had been affected.

Morgan[5] was unable to find in the literature any mention of regeneration among echini. The present observations may consequently help to fill a gap at that point, since I am not aware that any one has previously commented upon the matter, although the conditions described are perhaps well known to other students of echinoderms. For *M. pentapora* cases have indeed been noted in which a lunule, unclosed, extended to the periphery of the disc; but these instances have been referred either to accidental injury or to delayed growth, and "repair" phenomena seem not to have been observed. In *M. sexiesperforata* regeneration (of a sort) does undoubtedly occur, giving evidence of a respectable degree of plasticity in a stony structure where such might not be expected.

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[5] "Regeneration" (1901), p. 105.